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OPERATION OF A TRANSDUCER INFORMATION CENTER

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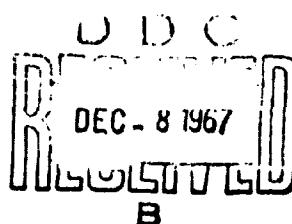
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BATTELLE MEMORIAL INSTITUTE
Columbus, Ohio

TECHNICAL REPORT AFFDL-TR-67-154

November, 1967

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AIR FORCE FLIGHT DYNAMICS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This report was prepared by Battelle Memorial Institute of Columbus, Ohio, on Air Force Contract No. AF 33(615)-5158, under Task No. 822203 of Project No. 8222, "Transducer Information Center". The work was administered under the direction of the Air Force Flight Dynamics Laboratory, Research and Technology Division. Mr. W. G. James (FDCL) was project engineer for the Laboratory. The assistance provided during the course of this program by Mr. James, H. Snowball, Dr. Paul Polishuk, and others at the Laboratory is gratefully acknowledged.

The work reported began on May 15, 1966, and was concluded on September 14, 1967. Thus, a 60-day period of work under the previous Contract No. AF 33(615)-2532 was not reported in AFFDL-TR-66-66 and is included in this report. W. E. Chapin, with the assistance of C. L. Hanks, H. T. Gruber, J. W. Klapheke, and C. B. Minor, had immediate responsibility for this activity, and Mr. E. N. Wyler supported the program through his supervision. G. L. McCann managed the various phases of information research. Mr. W. H. Veazie provided assistance to the Transducer Information Center group by devoting a portion of his effort at the Battelle-Los Angeles Office. This report was submitted for distribution on September 15, 1967.

This is the final report; it describes the operation of a transducer information center (TIC) for a period of 16 months following the completion of AF 33(615)-5158. The current contract was originally established for 12 months but was amended to include a 4-month extension. The 4-month extension constituted a reduced effort or one with an objective of maintaining a "keep-alive" status of the Center. The effort was designed to maintain abreastness of transducer developments and to provide limited technical services. The Center operation for the first 12 months consisted of reviewing and analyzing transducer information, supporting visits of qualified persons seeking information, providing assistance by responses to inquiries, preparing and distributing accession lists covering transducer documents and information, and preparing special technical reports. During the extended 4-month period, the Center continued to collect pertinent information but it limited its analyzations to filing purposes, and handled searches related to technical services requested by Air Force agencies and their contractors.

The authors wish to acknowledge assistance and cooperation so generously provided by researchers, users, and manufacturers of transducers, who promptly responded by completing and forwarding information forms and reports on their research activities and who supplied information on their new product developments. The assistance provided by various groups of the Instrument Society of America, the Chemical Propulsion Information Agency, research scientists at the Massachusetts Institute of Technology, and those of the National Bureau of Standards at Washington, D.C., and Boulder, Colorado, is also greatly appreciated.

Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions herein. It is published only for the exchange and stimulation of ideas.

W. W. Basham
Chief, Control Elements Branch
Flight Control Division
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ABSTRACT

This is the final report covering the operation of the Transducer Information Center (TIC) for the past 16 months at Battelle Memorial Institute under Air Force Contract No. AF 33(615)-5158, Task No. 822203 of Project No. 8222. This project involved the collection and processing of all categories of transducer documents, data, literature, and reports into a storage-and-retrieval system. The Center made this information available to the transducer-technology community on request by publishing accession lists or abstracts, research-contract compilations, a summary report covering nuclear-radiation effects on transducers and a monthly compilation of journal tables of contents. Members of the Center visited with manufacturers and users of transducers where discussions were held on the program objectives and the Center services. Over 1000 requests for technical and nontechnical assistance were handled by the TIC specialists. In its fourth year of operation, the Center has experienced a growth from a small-scale or pilot transducer information center to one which has met with favorable reaction and acceptance by its users.

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OPERATION OF A TRANSDUCER INFORMATION CENTER

by

W. E. Chapin, G. L. McCann, and W. H. Veazie

INTRODUCTION

Before 1960, systems for channeling, telemetering, and data processing for most transducers had advanced beyond the state of the art in accuracy and application versatility of the transducers available. The state-of-the-art disparity between sensory and conversion devices and the systems that utilized transducer output signals was discovered by a committee of the Instrumentation Branch of the Aeronautical Systems Division, who made a detailed assessment of telemetry transducers. As a result of the Air Force's "in-house" studies and other research programs, a recommendation was made that a central organization be created to collect and disseminate all forms of transducer information on a current basis. This recommendation was predicated on the fact that there was a definite lack of communication among transducer users, manufacturers, and developers. The notable trend for increased application of transducers and control-device improvements and industrial-process automation, in research-laboratory measurements, rocketry and missile programs, and the aerospace field further emphasized the need for an extensive system for nationwide dissemination of transducer knowledge and technological experience.

To fulfill this need, Battelle Memorial Institute proposed and contracted to conduct a program that had as its ultimate goal establishment of a transducer information center. Between April 15, 1963, and April 15, 1964, a study was conducted dealing with information-research concepts and the operation of a pilot-size information center. Under Air Force Contract No. AF 33(657)-11083, the need and methods were determined and resolved for a center that would provide useful information and assistance to the transducer technical community. Under Air Force Contract No. AF 33(615)-1812 and AF 33(615)-2532, the operation was expanded to the level of a small-scale transducer information center (TIC). The tasks of the latter two phases of the program were to determine the necessary implementation techniques and to demonstrate feasibility and final scope of operation of a TIC through actual application of the concepts derived from the continued study. In essence, the informational needs of the transducer community were being constantly assessed, and techniques for satisfying TIC users' demands were varied to conform with current needs. This type of operation necessitated providing for TIC modifications on a current basis so that adjustments could be made to concur with trends and developments in new areas of interest.

Under Air Force Contract No. AF 33(615)-5158 and its amendment, the TIC functioned as a full-scale information center for 12 months by reviewing and analyzing transducer information for the purpose of providing rapid answers to inquiries by users, supporting visits of qualified persons seeking information, and allowing preparation of special technical reports. During the latter 4 months as provided by the contract amendment, the Center continued to collect transducer information, but restricted its processing. At the same time it provided services to the Air Force Agencies and their contractors. This report summarizes activities of the TIC under Contract No. AF 33(615)-5158 from May 15, 1966 to September 14, 1967.

SUMMARY

During the specified contract period, personnel of the TIC, (1) provided technical and nontechnical assistance to transducer manufacturers and users, (2) visited manufacturers and users to discuss TIC objectives and services, (3) provided representation at conferences, symposia, and workshops, (4) prepared and distributed four quarterly accession lists, (5) prepared and published two research and testing contract compilations, (6) processed and distributed a state-of-the-art report describing nuclear-radiation effects on transducers, (7) processed and distributed a monthly compilation of journal tables of contents pertinent to transducer and instrumentation articles, (8) assisted faculties and students at educational institutions, (9) abstracted and extracted transducer reports and literature for storage and subsequent retrieval to satisfy requests for specific information, and (10) admitted qualified visitors to the center and provided them with assistance during their search for information.

The TIC initiated an intensive program during this contract period of screening, document procurement, and the processing of select transducer information and data. The information received was logged by the information specialists and extracted by technical personnel. After processing, the information was placed in the storage-and-retrieval files. Approximately 2300 items of information were processed into the system. This brought the total number of information items accumulated in slightly more than 4 years of operation to nearly 7000.

One hundred and thirty-eight manufacturers of transducers and 66 users of transducers were visited by the TIC personnel. This represents more than twice the number of organizations visited during the previous contract period. These visits provided first-hand information to many potential users of the TIC. Also, the visits provided useful information to the TIC system. As a result of these visits, TIC representatives were able to describe the center objectives, services, and capabilities far better than could have been done by using brochures alone. As a result of personal contacts, the number of requests showed a significant increase for the services and publications of the TIC.

The TIC information specialists selected approximately 75 current document abstracts each quarter and compiled them in a published accession list. Copies of these accession lists were mailed to all individuals on the TIC distribution list. Announcements in the Defense Documentation Center TAB and other similar listings of the accession lists produced many requests for copies. Requests were so numerous for some of the lists, that it was necessary to process extra copies.

Considerable interest in the "Research and Testing Contract Compilations" prepared by the TIC during the past 2 years was shown during this contract when the TIC produced a third and fourth compilation. It was found that program directors and project-development managers considered this phase of the TIC operation to be essential to their interests.

The TIC received approximately 1000 requests for technical and nontechnical information during the past 16 months. This represented an increase of approximately 125 percent over the previous 12 months. An analysis of these requests showed that approximately 58 percent were nontechnical and the remainder were technical or of the type that required studies by personnel with technical backgrounds. To date, approximately 1000 copies of the TIC publications have been sent to requestors by the Defense Documentation Center. The majority of technical requests dealt with transducers of the

pressure, temperature, displacement, acceleration, strain, gyroscopic, and shock types. Requests for information on nuclear-radiation effects on transducers led to preparation of a state-of-the-art report on the subject. Nontechnical requests were for quarterly accessions lists, contract compilations, and various summary reports.

TIC staff members attended conferences, symposia, and workshops. Attendance at these meetings provided opportunities to discuss TIC operations and services, and frequently resulted in further requests for information.

A study was made to determine the value of the TIC services in terms of tangible savings realized by the users for the previous as well as the current contract period. Survey results covering the previous period of the TIC operation indicated that the users felt that they had realized a total saving of \$462, 890. Many of the TIC users stated that they were unable to associate savings with the value of the services provided by the TIC. During the current contract period, a similar study was made. The total estimated tangible savings add up to \$495, 770. Approximately one-third of the TIC users replied to the inquiry by stating they felt that the center has been making major contributions to the state of the art, but that they were unable to estimate savings that resulted from its use.

During the past 16 months, the TIC has strived to expand its associations with educational institutions and to cooperate with members of their faculty and graduate schools as much as possible. In this manner, assistance was given to students and to the faculty of 30 colleges and universities. Some of the information was put to use by students during their theses work, whereas the faculty members found the information in the TIC publications useful in preparing lectures and class discussion.

TIC SERVICES AND TECHNICAL ACTIVITIES

The most significant services and activities of the TIC during the past 16 months of operation consisted of:

- (1) Providing technical and nontechnical assistance to transducer manufacturers and users
- (2) Visiting manufacturers and users to discuss TIC objectives and services
- (3) Providing representation at conferences, symposia, and workshops
- (4) Preparing and distributing quarterly accessions lists
- (5) Preparing and publishing two research contract compilations
- (6) Publication of a state-of-the-art report describing the nuclear-radiation effects on transducers
- (7) Distributing and publishing a monthly compilation of journal tables of contents pertinent to transducer and instrumentation articles

- (8) Assisting faculties and students at educational institutions
- (9) Abstracting and extracting transducer reports and literature for storage and subsequent retrieval to satisfy requests for specific information
- (10) Admission of visitors to the center and providing them with assistance during their search for information.

TIC Services to Transducer Manufacturers and Users

During the past 16 months, TIC staff members were approached for information and data by transducer manufacturers and users, technical journal publishers, and by those conducting research on the development of transducers. These contacts were established by letters, telephone calls, telegraph, and by visits to the TIC facility. Requests were also received by personal contacts at conferences and by visits to transducer manufacturers and users. The total number of requests handled for both technical and nontechnical information during the 16-month period was over 1000. Technical services are defined as assistance involving solution of some measurement problem or one that requires the services of a Battelle technical specialist. Nontechnical assistance necessitated a nominal amount of technical analysis and study, and usually consisted of requests for quarterly accession lists and other TIC publications.

A comparison of services for the current 16-month period and similar services for the preceding three 12-month periods is shown in Figure 1. The figure shows that there was an increase in current activity of approximately 125 percent in the TIC services over the previous 12-month period. The number of requests per month for this year ranged between 19 and 66, with an average of 40 per month or two per working day. The calendar months of June and September were most active with 66 and 62 requests being handled, respectively. In a pronounced number of instances, the technical requests were multiple in nature. That is, some requests were received where assistance was requested in a number of measurement problems dealing with a broad variety of measurands and their respective characteristics. A number of factors contributed to the increase in services during the current period of operation. The greatly accelerated program of visiting manufacturers and users to discuss the TIC operations, and attending conferences were found extremely successful in increasing the number of potential center users.

Nontechnical Services

In reviewing the number of responses to nontechnical requests during the past 16 months, it was observed that they totaled approximately 430, and consisted mainly of requests for (1) the TIC brochure, (2) the TIC accession lists, (3) research contract compilations, (4) the TIC summary reports on digital transducers, load cells, and nuclear-radiation effects, and (5) literature searches for bibliographies. In most cases where the brochures were sent to individuals requesting information on the TIC operations, the recipients frequently followed up by asking to be included on the TIC mailing list and to have all previous publications sent to them. The announcements and abstracts of TIC publications appearing in the Defense Documentation Center Bulletins and the

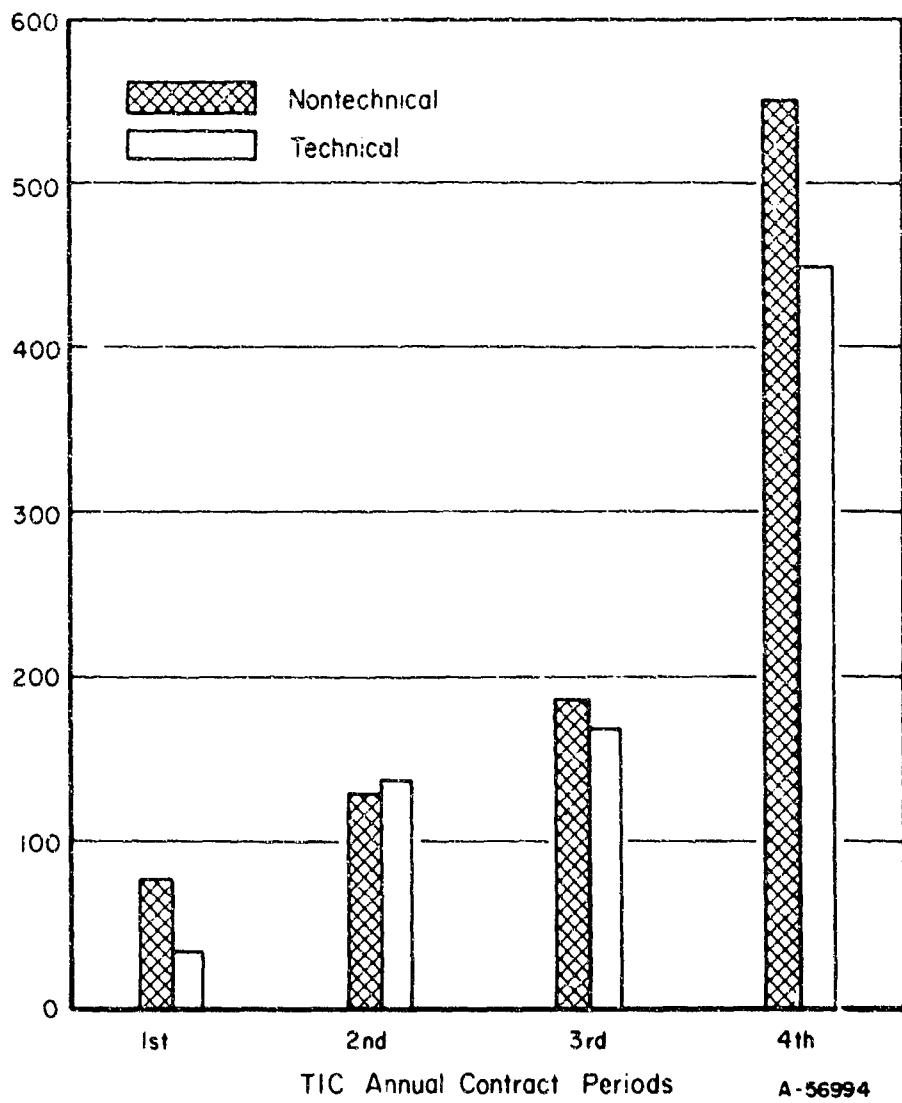


FIGURE 1. TRENDS AND COMPARISONS OF THE TECHNICAL AND NONTECHNICAL SERVICES PROVIDED BY THE TIC FOR EACH CONTRACT PERIOD

Clearinghouse for Scientific and Technical Information were responsible for more than 1000 requests for the center's publications. Over 300 copies of the TIC Summary Report Number 1 on Digital Transducers and 250 copies of the TIC Summary Report Number 2 on Force Transducers have been distributed to date.

Technical Services

Approximately 347 requests for technical information were handled. Table I lists these requests by types of transducers to show where the greatest interest appeared. Requests of a general nature included sensors that are normally used in a variety of transducers such as pressure, acceleration, displacement, and others that were related solely to transfer principles involved in transduction. Materials used in the design and construction of transducers are included in the specific types listed since the requester often stated his particular application.

TABLE I. LIST OF REQUESTS FOR INFORMATION
REQUIRING TECHNICAL ASSISTANCE BY
TIC STAFF SPECIALISTS

Subject of Request	Number of Requests
Pressure	96
Temperature	45
Displacement	29
Nuclear-radiation effects	19
General	16
Acceleration	19
Stress and strain	18
Gyros	16
Flow	18
Shock	9
Humidity	13
Velocity	7
Force	6
Vibration	6
Digital transducers	7
Tachometers	3
Attitude	3
Altitude	3
Biophysics	4
Chemical transducers	3
Liquid level	8

Interest in the nuclear-radiation effects on transducers, although not clearly indicated in Table I, has shown an increase because of the activity in NASA's NERVA program. This is not shown because such requests were handled principally by the Radiation Effects Information Center with the assistance of the TIC. The TIC has continued to limit its collection of such information to avoid duplication of effort with the Radiation Effects Information Center. Because of the large number of requests for such information, the

TIC and REIC combined their efforts and produced a report covering the subject of nuclear-radiation effects.

An analysis of the services performed by the TIC for the user and manufacturer groups was made. The results of this study are shown in Table II. In defining the characteristics of each group, it was realized that organizations who manufacture and use transducers do exist and therefore, they have been listed in both categories. It was also realized that users could include organizations such as educational institutions, technical consultants, information centers, and science libraries, as well as organizations that make direct application of transducers or perform research on their development. During the past year's operation of the TIC, the applicators of transducers used the services of the TIC to a greater extent than those who were connected with manufacturing. At the beginning of the current year of operation, this situation was recognized, and potential transducer-user organizations were encouraged to utilize the services of the TIC. Similar efforts were undertaken to make more manufacturers aware of the TIC. Requests for both categories increased significantly.

TABLE II. RESULTS FROM ANALYSIS OF TECHNICAL AND NONTECHNICAL SERVICES

Type of Service	Requests Handled	
	Transducer Manufacturers	Transducer Users
Technical	127	208
Nontechnical	180	283

Examples of Technical Services. In reviewing the technical requests handled by the TIC during the 16-month period of operation, certain trends have been noted which would indicate that transducer state of the art has not advanced sufficiently to meet the demand of the users of transducers. In some of the requests there are indications that manufacturers are concerned and have taken steps to investigate possibilities of improving their product lines. Typical examples were inquiries covering quartz-crystal materials and microsyn components for gyros. In regard to the investigation of quartz characteristics, the inquiries implied that an increasing number of companies are becoming interested in the use of quartz pressure-sensing elements. The search for information dealing with microsyns indicated that considerable research had been done in the last decade with the results being obscure in reports that were not readily available. The search indicated that few manufacturers were engaged in producing microsyns as an individual component.

The interest in integrated transducers was noted to be increasing at the manufacturing level. In handling requests for information on integrated transducers, the search into the TIC files was successful in retrieving information stored on the subject as far back as the first year of the TIC operation.

A trend for manufacturers of temperature transducers to develop platinum film-type resistance units has been noted due to requests for information on deposition techniques used for single-crystal and polycrystal alumina strata. A search into the manufacturer's file showed only a few manufacturers were already producing resistance-temperature transducers. The search effort for deposition techniques was Battelle-wide

and included investigations of manufacturing procedures used by resistor manufacturers who have specialized in the use of noble metals.

In the area of high-frequency-response dynamic-pressure transducers, the requirements for responses less than 2 microseconds has begun to show. Searches made in the manufacturer's files indicated that the state of the art was for a frequency range between 250 and 500 KHz. Further investigations located information concerning evaluations of a number of transducers to determine which possessed the best frequency responses. In one reported instance, a transducer using tourmaline was found to have a response less than 1 microsecond.

At approximately midway in this contract year, a strong interest was being shown in measurements of shock impacts in three axes. These inquiries were primarily searches for available sources of transducers. It was interesting to note that much had been done during the past 4 years along these lines, with information being reported annually at the Shock and Vibration Symposia. Of major interest was that the reported information indicated each time that the research groups designed and constructed their own shock-measuring systems at substantial cost at their laboratories for coast-to-coast transportation studies. This practice was considered unusual since such apparatus have been available from several commercial sources for some time, and such information could have been provided to the researchers to give them some tangible savings.

During the past year, the TIC has been keenly aware of transducer problems associated with the liquid-metal media and has reacted by establishing an awareness program to collect any literature dealing with transducers used in such applications. This effort began early in the current year after a request was received from NASA-Lewis Research Center in connection with liquid-metal pressure transducers. The request pointed out an area where little information was readily available and one in which future consideration will have to be made to provide improved dissemination and cooperation with other centers. It was soon recognized that such information has been generated by groups active under AEC programs. The first step was to search for information in the AEC library at Battelle. Some information was found which pointed to various approaches reported for pressure measurements of liquid potassium at temperatures between 800 and 1000 C. No transducer manufacturers made claims in their literature that the materials in their bellows, bourdon tubes, or diaphragms were compatible with liquid sodium, potassium, etc. Important information was found concerning the existence of a "Liquid Metals Information Center" in Los Angeles, which had begun operations recently. The names of personnel who could handle requests concerning measurements in liquid-metal systems were obtained and all other information collected was sent to the requester at the Lewis Research Center. A continued effort was made to probe commercial sources for liquid-metal pressure transducers, and several manufacturers were found who indicated that they had developed the necessary capabilities for producing transducers that operate in liquid metals.

The TIC has found numerous occasions where various research projects at Battelle have used its services in transducer developments. One such occasion occurred where Battelle inertial specialists were examining the possibilities for the development of an angular accelerometer switch with modifications involving a potentiometric element for an inexpensive inertial-type angular accelerometer. The switch development was related to an application for sensing inertial forces during third-stage spin-up for actuating the launch sequence timers in a spacecraft. The switch portion consisted of a balanced rotor with a high moment of inertia. The balanced rotor was restrained angularly

by magnetic action caused by a detent screw being attracted to the magnet and by a spring in a microswitch exerting a centering force. The study was made to determine whether similar principles were in use for the accelerometer switch and again to determine whether modifications could be made to use the technique for measuring or sensing angular acceleration. The TIC information searches indicated that the potentiometric means for linear acceleration measurement and sensing was commonly used; however, no information was found where potentiometric methods were used to measure angular acceleration.

Visits to Manufacturers and Users

The experience gained during the past 3 years of the TIC operation has clearly shown that one of the most important aspects connected with promotion of an active center is direct contact with its potential users. This has become vitally necessary to ascertain user requirements and to ensure that these requirements are being fulfilled.

Utilization of all means possible to disseminate information on the TIC's existence, services, and objectives was always considered essential. The methods used to inform the transducer community of the services available to them included (1) visits to manufacturers and their district representatives, (2) conferences with the instrumentation groups, researchers and developers, and transducer technologists, and (3) providing for TIC representation and participation in conferences, symposia, and workshops, and assisting in the development of sessions for workshop groups. The most rewarding approach used during this 16-month period was to establish a base of operations at the Battelle-Los Angeles office. This was accomplished by assigning a TIC representative to concentrate a portion of his overall effort in Los Angeles and its vicinity since that section has the greatest concentration of manufacturers and users of transducers in the country.

Contact With Transducer Users and Researchers. Sixty-six transducer-user organizations were visited. The organizations visited were:

FDCL, RTD, WPAFB	Lowry Air Force Base (TSVP)
NBS Boulder	Beech Aircraft Corporation
Lockheed Missiles & Space Co.	Philco Corporation
General Electric Co. California	University of California
Sandia Corporation	Stanford Research Institute
Bureau of Naval Weapons	Lear Siegler, Inc.
Douglas Aircraft	Edgerton, Germeshausen & Grier, Inc.
Metrophysics, Inc.	Hercules Powder Company
Univ. of California (LA)	Garrett Corporation
North American/Autonetics	Ling Electronics, Inc.
General Dynamics/Convair	General Dynamics/Rocketdyne
General Dynamics/Electronics	North American Aviation/Space Systems
Spacelabs, Incorporated	NASA, Flight Research Center
USAF Rocket Propulsion Labs.	AFRPL, AFSC
U.S. Naval Ordnance Test Station	NBS-Washington
NBS-Gaithersburg	Electrocraft, Inc.
John Hopkins University	Scope, Incorporated
George Washington University	Instrument Society of America
Ford-Philco Corporation	San Fernando Laboratories
Lockheed-California Company	California Alloy Products

Northrop/Nortronics	Aerojet-General
Douglas Aircraft Co., Santa Monica	Hughes Aircraft Company
Litton Industries	North American Aviation/Downey
North American Aviation/AID	Aerospace Corporation
Marquardt Corporation	Aerojet/Reon
Sandia Corporation/Albuquerque	ITT Cannon Electric Company
Douglas Aircraft/MSSD	Hughes Aircraft Company, Newport
Leach Control Corporation	Sperry Phoenix Company
JPL, Pasadena	JPL/Edwards
TRW, Space Technology Labs.	USN Fleet Missile Systems
Space Ordnance Systems, Inc.	Perkin-Elmer Corporation
NASA Western Support Office	Research Data Corporation
Scranton Engineering	Aerospace Corporation/San Bernardino

The individuals visited at the above-named organizations included instrumentation and test engineers, science librarians, application engineers, and program coordinators and planners. On each visit the reasons for organizing a TIC were discussed. In a number of instances, the persons visited were aware of the TIC's existence through quarterly accession lists that they were receiving from the Defense Documentation Center. However, the remaining services of the center were not clearly understood. By such contacts it was possible to reply personally to many questions, resulting in a clear understanding of the TIC operation along with increased utilization of the center's services.

During these visits, transducer-application engineers discussed their problem areas and immediate needs. In some cases, the visited specialists indicated that their fields of interest would continue to be in one type of measurement for an indefinite period of time. In such cases, they frequently requested that they be apprised of new techniques and developments in their area of interest as they occur. The measurements and standards laboratories were viewed by TIC representatives on such visits, thereby giving them a firsthand impression of the actual problems encountered in complex test and measurement applications.

Contacts with Manufacturers. One hundred and thirty-eight manufacturers of transducers and instruments were visited during the past 16 months of the TIC operation. The organizations visited were:

Aero Mechanisms, Inc.	Solid State Electronics Corporation
ATA Engineering Company	Digital Sensors, Incorporated
Bourns, Incorporated	Flowcon Corporation
Data Sensors, Inc.	Endevco Corporation
W. C. Dillon & Company	Lunar Engineering Corporation
Electro Optical Systems	Leach Control Corporation
Gyrex Corporation	General Nucleonics Corporation
Helco Products Corporation	Northrop Ventura
Honeywell, Incorporated	Scientific Engineering and Manufacturing
Hy Con Mfg. Company	Marshall Instruments, Inc.
Kavlico Electronics, Inc.	Celtic Industries, Inc.
Hydrodynamics, Incorporated	API Instruments Company
Wilcoxin Research	Airesearch Manufacturing Company
Klixon, Incorporated	Genisco Systems
Thermal-Elements	Electra Scientific Corporation

Latronics Corporation
Remes/Rheems Electronics
BMA Corporation
Auto Controls Corporation
Hammarstrom Controls Company
Martin-Decker Corporation
Barber-Colman Company
Transmetrics, Incorporated
Physical Sciences Corporation
Vacco Valve Company
Trusonic
Voltron Products
Glassco Instrument Company
Lockheed Electronics
Tylan, Incorporated
Metron Instruments
Kaman Nuclear
 CM^2 Incorporated
Giannini Controls Corporation
TEMTECH
Yellow Springs Instrument Company
Kulite Semiconductor Products, Inc.
Ormond, Incorporated
Advance Components Corporation
Apollo Electronics Company
Beckman Instruments, Inc.
BLH Electronics
California Alloy Products Company
Consolidated Electrodynamics Corp.
Do All Company
Electro Products Laboratories, Inc.
Guidance Technology, Inc.
Hydra-Electric Company
James Electronics
Kinelogic
Ling Electronics
Marcal Electro-Sonics
Mechmetals Corporation
Microdot, Incorporated
Pacific Transducer Company
Power Engineering and Equipment Co.
Reotemp Instrument Company
John B. Rudy Company
Sensing Devices, Incorporated
Space Labs, Incorporated
SPEC Tool Company
Systems Research Corporation
Transducer Measurement Company
Volumetrics, Inc.
Wavelabs Company
Whittaker Corporation
 Y^2 Associates, Incorporated
Perkin Elmer Corporation
Weston Instruments

Beckman Instruments, Inc.
Teledyne Systems Company
Avionics Research Products Corporation
Wavelabs Company
Humphrey, Incorporated
Numerical Control Corporation
Bisett-Berman Corporation
Biocom, Incorporated
Spacelabs, Incorporated
Foxboro Corporation
Hewlett Packard
Edcliff Instruments
Hy-Cal Engineering
Relco Products
Cryogenic Research
Master Products Mfg. Company
General Transducer Company
Industrial Measurement Company
West Coast Research Company
Solid State Radiation, Inc.
Robertshaw Controls
Kistler Instrument Company
Aero Research Instruments
American Standard
B & K Instruments, Inc.
Beckman & Whitney, Inc.
Bolt, Beranek and Newman, Inc.
G. L. Collins Corporation
Delta Sonics, Inc.
Electro-Oceanics
Garrett Corporation
Gulton Industries
ITT General Controls
Kenelco, Incorporated
Lear Siegler, Incorporated
Magnaflux Corporation
Martin-Decker Corporation
Metrophysics, Incorporated
Nova-Netics
Photocon Research Products
Power Instruments, Incorporated
Rotiform
San Fernando Laboratories
Servonic Instruments, Inc.
Sparton Southwest, Incorporated
Statham Instruments, Inc.
Transducers, Incorporated
Trusonic
William Wahl Corporation
West Instrument Company
Winsco Instrument and Controls Co.
Space Technology Labs, Inc.
The Budd Company
Barksdale Valve Company

Individuals visited at the above-named organizations were research and development engineers, product development and design engineers, science librarians, and production managers. These companies were given presentations similar to those for users of transducers. In cases where the company was both a user and a manufacturer, both groups were briefed. One of the important advantages of the visits made to transducer manufacturers was the procurement of information on new product lines and future developments. Also, some developments in the past that were seldom or never advertised, "one-of-a-kind" transducers were discussed and information on them was obtained. In some instances, manufacturer's representatives were asked questions to obtain additional information needed for past requests handled by the TIC. In a number of such cases, long-sought information from manufacturers was obtained and forwarded as a follow-up service connected with a past inquiry.

Conferences, Symposia, and Workshops

Three meetings were attended by the TIC representatives during the past 16 months. These were:

- (1) The Fourth Static Testing Group Workshop (CPIA)
- (2) The 36th Symposium on Shock, Vibration, Acceleration and Associated Environments
- (3) The 21st Annual Conference and Exhibits of the Instrument Society of America.

Attendance and participation at the Fourth Static Testing Group Workshop Meeting provided an ideal opportunity to distribute copies of the TIC Summary Report Number 2, which covered the subject of load cells and force transducers. The report was prepared because a previous meeting and subject discussion showed that there was a need for such information. Favorable reactions were observed when copies were being examined by the recipients. Requests for specific information needed by various members who volunteered papers for the next workshop were made of the TIC and questions pertaining to the TIC services were answered during panel discussions.

The ISA Conference and Exhibits provided a large number of reprints for entry into the TIC files. Some of these were of immediate use in the handling of replies to requests for information that were current. Manufacturer's representatives were briefed at their exhibits and some new developments were discussed. Manufacturers were questioned on the availability of certain unusual transducers which the TIC has been able to find only limited information on.

Papers presented at the 36th Shock and Vibration Symposium of interest to the TIC concerned accelerometer calibration techniques and applications. Information dispensed on developments of velocity shock recorders for use in studies of shipping environments were of major interest to the TIC since such activities are being followed by a sizeable group of individuals who have been using the TIC. Another area of particular interest involved information on the development of a low-cost force transducer which uses ferroelectric materials as a sensor. The facts that the transducer costs less than commercially available transducers and possesses approximately ten times the conventional sensitivity were of considerable interest.

TIC Services to Educational Institutions and Establishments

After operation of the TIC for the past 4 years in various stages of growth, numerous educational institutions have become aware of the center's function, and have approached the TIC for its services and publications. The TIC distribution list includes 30 colleges, universities, and training centers. These organizations are:

- | | |
|---|---|
| (1) Arizona State University | (18) University of California |
| (2) Cornell University | (19) University of Nevada |
| (3) Dartmouth College | (20) University of Pennsylvania |
| (4) Dayton University | (21) U.S. Naval Training Device
Center |
| (5) George Washington University | (22) Michigan Technological
University |
| (6) Illinois Institute of Technology | (23) Weber College |
| (7) Johns Hopkins University | (24) Michigan State University |
| (8) Massachusetts Institute of Technology | (25) Stanford University |
| (9) New York University | (26) 3750 USAF Tech. School |
| (10) Ohio State University | (27) Univ. of Massachusetts |
| (11) Princeton University | (28) University of Detroit |
| (12) Purdue University | (29) University of Texas |
| (13) San Jose State College | (30) University of Washington |
| (14) Texas A & M University | |
| (15) Texas Western College | |
| (16) TME Branch-Lowry Air Force Base | |
| (17) University of Wisconsin | |

Assistance to faculty members and students at universities and other educational institutions has always been an objective of the TIC. Some of the services the TIC has been providing are connected with graduate school work. In some cases where special courses in instrumentation is being offered undergraduate students, faculty members have used the TIC publications as an aid to lecture preparation. This has been pointed out because there are no accepted textbooks published for classroom usage. Another example of cooperation with educational institutions is one that can be cited for Arizona State University where each year a special short-term course is offered in engineering instrumentation. The TIC has distributed announcements of the special course each year with routine mailings of the center publications. Also, faculty members associated with various research institutes attached to the universities have been using the TIC as a source for keeping abreast of instrumentation developments. Many brochures explaining TIC's services and objectives have been distributed among participants at sessions held at the Arizona State University.

Services to Government Agencies

The services provided by the TIC to Government agencies can best be shown by the following list of groups that have been on the center's distribution list.

U. S. Air Force	U. S. Navy
Wright-Patterson Air Force Base, FDCL	U. S. Naval Air Station, Lakehurst
Newark Air Force Station	U. S. Naval Applied Science Laboratory
Arnold Air Force Station (AEDC)	U. S. Naval Avionics Facility
Edwards AFB (6)	U. S. Naval Missile Center, Point Mugu (2)
L. G. Hanscomb Field (2)	U. S. Naval Ordnance Test Station (3)
WPAFB/SEG/AFSC	U. S. Naval Training Device Center
Lowry Air Force Base	Metrology Engineering Center
Sheppard AF Base	Bureau of Naval Weapons
Redstone Arsenal	Philadelphia Naval Shipyard
Hercules Powder Company (Bacchus)	David Taylor Model Basin
	Hercules Powder Company (Cumberland)(3)
Department of Commerce	Department of the Army
National Bureau of Standards (Boulder)(2)	Frankford Arsenal
National Bureau of Standards	Redstone Arsenal, AMC
Washington (5)	Picatinny Arsenal
Clearinghouse FSTD, Washington	
NASA	Department of Agriculture
NASA, Lewis Research Center (2)	Agricultural Research Service (2)
Marshall Space Flight Center	
NASA-Flight Research Center (2)	
NASA Headquarters	
G. C. Marshall Space Flight Center	
NASA-Goddard SFC	
NASA-OART	
NASA-STIF (S-AK/DL)	

Note: Figure in parentheses indicates number of different individuals at the same facility.

In reviewing the services provided to each of the above groups, several points are worthy of mention. The organizations named do not include all Government agencies receiving services in the form of TIC publications. Others in this category have from time to time requested publications, but have never formally requested that their names be placed on the TIC mailing list. Attempts were made to list all services extended to the above organizations, and to others not in the Government-agency category, that conduct research for those agencies. Accurate listing of such related services was not possible in the majority of cases because many requesters for services do not include information that would associate their work with a Government contract. However, services that were extended solely to Government agencies, exclusive of automatic mailings of TIC publications, were accurately assessed. A percentage breakdown of total services performed according to agency, and the part of total agencies for each category, is shown in Table III.

During the former contract year of the TIC operation, the U.S. Navy has increased its use of TIC to the point where Navy requests outnumber those of the U.S. Air Force. U.S. Navy individuals have used approximately one-third of the total services extended to Government agencies. The last three agencies shown in Table III do not show extensive use of the TIC's services because they have only been aware of the center's activities during the past 5 months. In general, most of the research groups using the TIC

Atomic Energy Commission

Union Carbide Corporation (3)
Battelle Northwest (2)
Brookhaven National Laboratory

services have used the center in proportion to numbers of their personnel on the distribution list.

TABLE III. BREAKDOWN OF SERVICES PERFORMED DURING PAST 12 MONTHS FOR GOVERNMENT AGENCIES

Government Agency	Request, percent	Government Agencies on Mailing List, percent(a)
U. S. Air Force	26	27
NASA	11	16
U. S. Navy	33	28
Department of Commerce	14	13
Atomic Energy Commission	7	8
U. S. Army	6	5
Dept. of Agriculture	3	3

(a) Based on a total of 60 agencies on current TIC mailing list.

Estimated Tangible Savings by Users of the TIC

It has been established that the real worth of an information center can be determined by assessing the extent of tangible savings realized by its users. The TIC has felt that in past years much of the assistance provided to the transducer community resulted in some savings. Therefore, at the outset of this current contract period, the TIC surveyed past users to determine the tangible savings they realized for the past year and for the current year. To stimulate the thinking of those asked to assess the value of the center, the following questions were asked:

- (1) How many design-dollars were saved?
- (2) Were any laboratory tests avoided?
- (3) How much time or money was saved in eliminating all or portions of literature searches that are often necessary prior to engaging in research and development?
- (4) How much time and money were saved during the process of design selections of commercially available transducers?
- (5) How much money was saved by preventing duplication of effort?

Approximately 250 individuals who were on the TIC mailing list were asked for information on tangible savings and 105 responded to the request. Of the total number that responded, one-third provided numeric answers. The remaining replies indicated that they were unable to estimate the value of the services even though they recognized that the services were valuable. The breakdown of estimated tangible savings by organization and the total amount for the 1965-1966 annual period is given in Table IV.

TABLE IV. ESTIMATED TANGIBLE SAVINGS REALIZED BY THE TIC USERS
DURING THE 1965-1966 PERIOD OF OPERATION

Types of Organizations	Estimated Savings
<u>(1) Nongovernment Organizations with Government Contracts</u>	
U.S. Air Force	\$89,100
U.S. Navy	57,640
Atomic Energy Commission	1,000
U.S. Army	15,150
NASA	83,050
<u>(2) Nongovernment-Associated Industries</u>	
Internal Operations Only	\$89,950
<u>(3) Government Agencies</u>	
U.S. Air Force	120,000
U.S. Navy	3,500
NASA	1,000
<u>(4) Colleges and Universities</u>	
Total	\$462,890

It can be seen in Table IV, which in several aspects is not complete, that those who were able to relate a tangible saving because of their use of the TIC services realized a total greater than six times the cost of operating the TIC in the 1965-1966 period. It is felt that the total would have been substantially greater if a majority of users possessed sufficient experience in performing information research and were familiar with the associated expenses. This is shown in comments given by many who responded without numerical information as shown in the following excerpts:

- (1) "An estimation of cost savings is indeterminable; however, the information provided by the center has great influence on our efforts in the area of research and development of new products and systems design."
- (2) "This activity has been receiving the TIC services since 1963. While it is not possible to realistically estimate dollar savings resulting from the use of your publications, it can be stated with certain assurance that the information contained therein is of great value. It is our opinion that the TIC group have made a major contribution to alleviate the eternal problem of keeping abreast of current techniques and developments in the transducer field."
- (3) "Since it is not possible for us to estimate a direct dollar saving, we are taking the liberty of extending our comments. We use a number of sources for information; however, not one of them is of more value than the Transducer Information Center. We have always found that the information is

current and pertinent to our activities. As such it has remained a valuable part of our research activities."

- (4) "We are unable to ascribe any tangible savings resulting from information supplied by the TIC. However, we consider the activity to provide a needed and worthwhile function, and desire to see the work continued. The reports are circulated within our Engineering organization, and are well received".

Current Period Tangible Savings Study. A similar approach was used to determine the extent of savings that were realized by the TIC users during the current contract period. The only difference in the current effort was that a large portion of the addressees' were those who made personal requests for assistance as opposed to those who were on the mailing list and may not have used the TIC beyond receiving its publications. It is believed that this approach was responsible for a rate of response that occurred. The results of this second study of tangible savings is given in Table V.

TABLE V. ESTIMATED TANGIBLE SAVINGS REALIZED BY THE TIC USERS DURING THE 1966-1967 PERIOD OF OPERATION

Types of Organizations	Estimated Savings
<u>(1) Nongovernment Organizations With Government Contracts</u>	
U.S. Air Force	\$106,870
U.S. Navy	37,300
Atomic Energy Commission	8,900
U.S. Army	23,700
National Bureau of Standards	21,000
NASA	96,900
DASA	1,000
<u>(2) Nongovernment-Associated Industries</u>	
Internal Operations Only	\$174,300
<u>(3) Government Agencies</u>	
U.S. Air Force	600
U.S. Navy	
U.S. Army	
NASA	2,000
<u>(4) Colleges and Universities</u>	
Nongovernment Associated Research and Development	23,200
Total	\$495,770

TECHNICAL INFORMATION ACQUISITION AND DATA FILES OPERATION

During the past 16 months of the TIC operation there was a reduction in the total number of documents processed into the system. However, a number of new factors were introduced in this contract which can be interpreted as growth and improvement of capabilities. Because of the experience gained by the TIC staff in recognizing information with future potential application and of interest to the TIC users, a large amount of incoming information was rejected as unsuitable because of poor readability, absence of technical data, incompatibility with the TIC definition of a transducer, and because the information had been processed into the center in other forms in the past.

The information specialists, because of their past experience, have been able to provide output services to the engineers in greater depth than has been the case in the past. When the center was faced with an extensive backlog of unprocessed documents at the beginning of this contract period, the personnel were able to reduce the inventory to a size which was considered normal. At the same time, the information specialists answered requests for two compilations of research and testing contracts, and four compilations of tables of contents from technical and scientific journals.

Sources and Acquisition of Information

The primary sources for research and evaluation reports covering transducer technology continue to be Technical Abstract Bulletins of the Defense Documentation Center, NASA's Scientific and Technical Aerospace Reports, International Aerospace Abstracts, and the Interservice Data Exchange Program's (IDEP) Summary Sheets and Reports. As of January 31, 1967, the TIC obtained 318 documents from DDC, and 381 reports from NASA's Scientific and Technical Information Facility. To increase the TIC coverage of transducer information, more than 50 technical and scientific journals were screened for pertinent articles. The increase from 30 journals of the past year to the present number resulted from experiences gained in searches outside the center and from suggestions made by recipients of the journal tables of contents compilations. The technical areas of medical electronics and oceanography, into which the TIC has made some inroads, were responsible to some degree for the increase in journals screened.

A significant source of information has been conference, symposia, and workshop proceedings and publications. These proceedings have been acquired largely through attendance at these various meetings, enabling the TIC to obtain information for the center at a much earlier date than would have been possible from the listed primary sources. In some cases, the proceedings were not distributed beyond those that attended and the center played an important role in making such information available to a larger community.

Many of the journals regularly scanned for information provided knowledge of new product developments through their advertisement sections. The general practice was to try to obtain additional information in a form adaptable for filing and subsequent retrieval. In this manner and by visiting manufacturers, the TIC was added to the manufacturers' mailing lists for all transducer information emanating from their product development and advertising sections. One of the greatest improvements or implementations to the TIC program involving manufacturers was the locating of a TIC representative

in Los Angeles, thus making it convenient for immediate contact and visitation in an area where the density of users and manufacturers is high.

Document-Processing System

The procedures followed for processing of transducer information have not changed to any major extent from the last operating year. Documents are received at the TIC from its many sources and they pass through an organized system of processing for ultimate storage and retrieval. Figure 2 is a detailed chart of document flow and processing. From this chart it can be seen that the processing of manufacturers' literature is considerably more abbreviated than that for research and test-evaluation documents. The processing of the trade literature is handled separately for the following reasons:

- (1) Economy - Because of the larger amount of trade literature and the ratio of useful information to promotional information, it is vital that this information be included at less cost than research and evaluation reports.
- (2) Nonstandard Form - Photoreduction by the Robinson camera makes reduction and reproduction of many sizes and types of manufacturers' literature possible.
- (3) Proprietary - Photoreduction eliminates the need to extract, abstract, or edit the manufacturers' literature. This eliminates the possibility of being unfair to one or more producers which may occur unintentionally should attempts be made to standardize formats or terminology.

The last two entries shown on the chart in Figure 2 indicate that many areas by which information can be retrieved from the files. For the purpose of clarity and brevity, the various measurands were not entered in detail on the chart. These are as follows: acceleration, acoustics, attitude, angle-of-attack, altitude, medical electronics, converters (A/D and D/A) density, displacement, flow, force, gyroscopic devices, humidity, liquid-level, magnetic radiation fields, motion, position, high, low, and partial pressures, rotational or angular speed, linear speed, shock, strain, stress, temperature, thickness, torque, velocity, vibration, and others.

Information Processing

Table VI presents a comparison of four successive 12-month contract periods of the TIC operation. The types of documents are listed to show interest trends and developments. Research reports represents a broad category of documents because of the many definitions associated with the term. In this instance, research includes information on both basic and applied research and, to some extent, developments beyond the state of the art are included. The drop in manufacturers' data sheets processed is a significant factor during the fourth period. The chief attribute to this decreasing trend is that product developments are not very rapid. Therefore, new product-line sheets are not appearing at the rate shown for previous years. The large number of these sheets shown for previous years represents to a great extent the effort expended by TIC to collect as much information as possible on available transducers. It should therefore

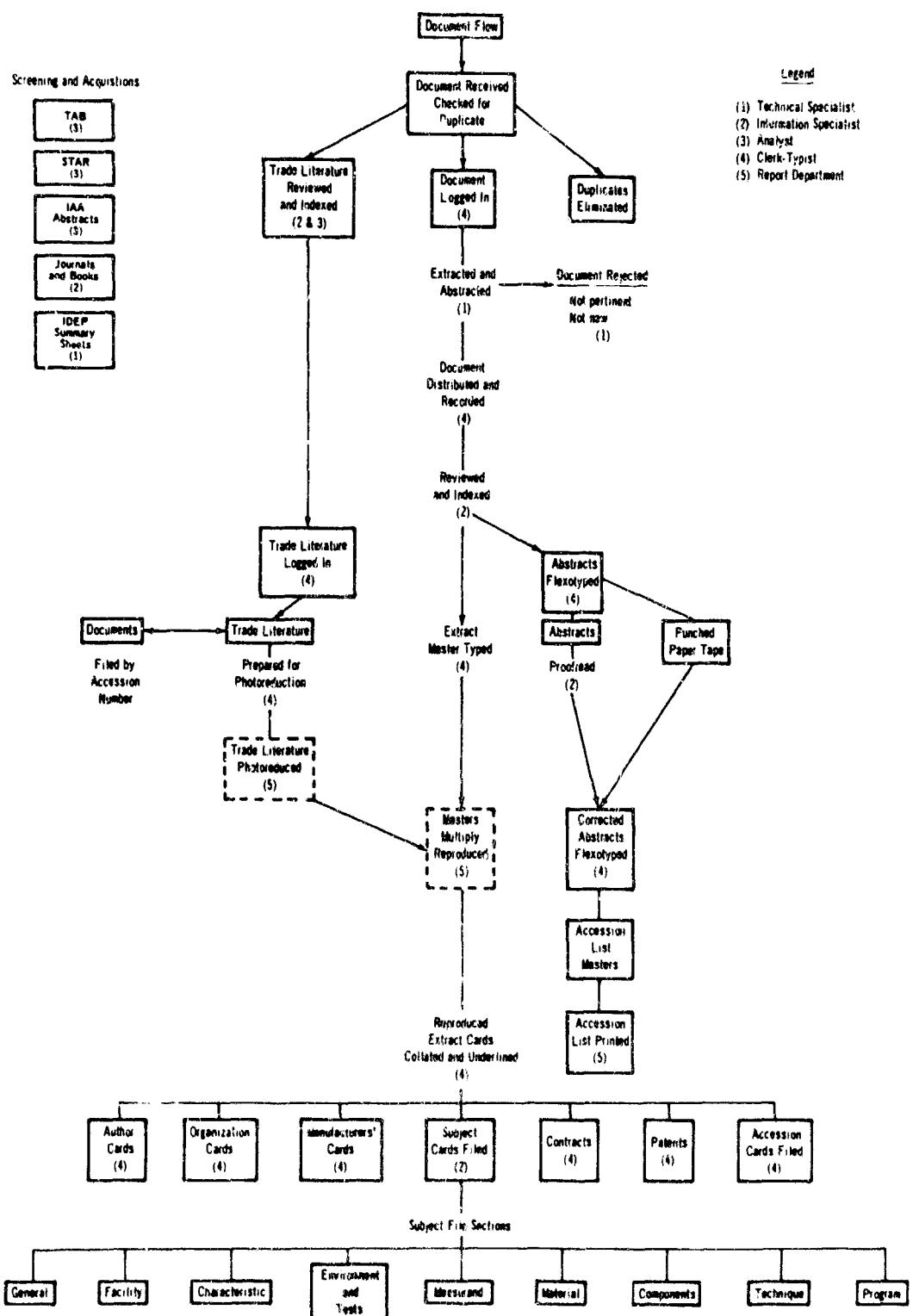


FIGURE 2. PROCESSING FLOW OF DOCUMENTS AND INFORMATION RECEIVED BY THE TIC

be expected that eventually nearly all of the information to be found has been collected for the TIC files. In regard to reports covering testing and evaluations of transducers, the flow of information into the TIC system is fairly uniform since the prime source (IDEP) has been reliable in submitting information to the Data Procurement Branch of Wright-Patterson Air Force Base. The substantial increase in journal articles included in the TIC files for the current annual period was caused chiefly by the nature of searches made at Battelle's science library for information that the center lacked. When searches were made for information generated before the TIC was organized and operating, the journal section was extremely useful. When applicable papers were found, the information was also processed into the center to prevent repetition of outside searches. Also, the interest shown in journal tables of contents compilations brought to the attention of the TIC periodicals that had not been screened in the past including some which have been publishing transducer articles from time to time.

TABLE VI. COMPARISON OF TIC INFORMATION PROCESSING FOR FOUR SUCCESSIVE 12-MONTH CONTRACTUAL PERIODS

Document Types	Contractual Periods				Total
	First	Second	Third(a)	Fourth(b)	
Research reports	243	512	1138	1098	2988
Evaluations	170	70	174	221	635
Specifications	5	3	50	34	92
Manufacturers' data	76	658	510	409	1653
Journal articles and surveys	98	74	281	510	963
Bibliographies	8	2	12	15	37
Total	600	1319	2165	2287	6368

(a) Data adjusted from estimated to actual for Third and Fourth Year.

(b) Includes data estimated from January 31 to May 15, 1967 (Reports and documents procured during 4-month extended period were not processed into the system, but merely logged).

Transducer Literature Backlog

One of the problems facing the establishment of an information center involves a decision as to whether information shall be collected on a current basis or whether both current and information generated in past years should be included. The TIC decided to collect information on a current basis because of limited funding, and included the possibility that searches for old information would remain for consideration according to the demand. Justification for such a decision was made on the basis that the Battelle science library with its store of journal articles, reports, and textbooks could adequately implement the TIC in searches for information generated within the past 2 decades. In reviewing the past 4 years of operation, the approach adopted in connection with literature backlog was found advantageous in that only past research reports and journal articles published before the TIC began operations were of interest to the center users. A listing of publications, reports, and informational items (as given in Table Table VII) that is now in the TIC files shows that prior to 1962, few requests were made which required the acquisition of documents generated before the TIC was organized.

TABLE VII. DOCUMENT INPUT FOR PAST 12-MONTH PERIOD BY TYPE AND BY YEAR OF GENERATION

Date of Report	Type of Reports			Type of Reports					Total
	Research Reports	Journal Articles	Evaluation Reports	State-of-the- Art Reports	Manufacturers' Data	Survey	Specifications	Others	
1947	1								1
1948	1								1
1950				1					1
1951	1								1
1953	1				1				2
1954	2				1				2
1955					1				3
1956	4				1				5
1957	2				1				2
1958	2				1				3
1959					2				2
1960	2		1						3
1961	4	2	4						11
1962	5	1	2	4					12
1963	17	6	4	8					40
1964	25	3	11	17	3	1	3		63
1965	233	4	60	80	9	17	11	2	416
1966	410	160	36	83	16	16	3	11	735
1967					1			1	1
No Date					93				93
Totals	708	178	115	203	123	37	21	13	1398(a)

(a) Total does not agree with fourth period total in Table VI since TIC does not include extracts typed but not reproduced. Input to the TIC during 4-month extension not included in inventory.

It can also be seen in Table VII that, of the 1418 items processed during the past 12 months, 1151, or 81 percent were generated in 1965 and 1966. Only 6 percent of the documents acquired and processed during this period were published prior to 1964. This is significant in indicating a good handling of the backlog problem and that the TIC acquired, processed, or rejected documents on the basis of document content rather than by age.

File Development and Terminology

The development and manipulation of the TIC clue-word index necessitates a considerable amount of time and effort. In order to file the information logically and efficiently and to ensure rapid and complete retrieval, it has been necessary to establish a Transducer Thesaurus. The ISA Transducer Compendium and the ISA Tentative Recommended Practice, "Nomenclature and Specification Terminology for Aerospace Test Transducers with Electrical Output" were utilized to a great extent in developing and defining the TIC index. It was apparent to the TIC staff that there is a great need for a standard vocabulary on transducer technology. The TIC index is in an embryotic stage; however, it has served as a basis for the development of a common thesaurus for most transducer users and manufacturers.

Information-Research Services and Activities

In addition to acquiring and processing transducer information and data into the TIC storage and retrieval system, the center maintained a distribution list for automatic mailing of TIC publications, selections of documents of current interest for preparing accession lists, collection of current research-contract information for compilation purposes, and compiled the tables of contents for journals being screened by the TIC staff. The information-research group also provided the searches for information which led to the preparation of the summary report on nuclear-radiation effects on transducers.

Distribution List

During the past 16 months of the TIC operation, there was a net gain of 29 percent in the distribution list. There were 95 new inclusions and 14 deletions. There are now 348 individuals or their organizations on the distribution list. In all cases the deletions involved individuals who were either no longer involved in transducer applications and technology, or who preferred that all future publications be sent to their science libraries. In many of the latter instances, the science libraries already were regularly receiving the TIC publications.

Accessions Lists

The Quarterly Accessions List continues to be one of the most popular services provided by the TIC. Four such publications, with a total of 309 abstracts covering the most recent and pertinent documents, were published and distributed during this contract year. The 309 abstracts represented 16 percent of the total number of documents processed by the TIC in this contract period. Selection of documents to be abstracted for

the accessions lists were based on the TIC staff's experience in answering requests and also a knowledge of the users' specific interest. As in the past, the user reaction to the accession list was favorable, even though some misconception of its intent was observed from time to time. Some recipients of the list were under the impression that the listings represented the entire literature accession of the center. Assurances were given in response to inquiries that the center possessed many more documents in its files. Occasionally, users of the TIC suggested that the center expand some of its areas of interest. Such suggestions were studied and action taken when accepted. A typical example of an accepted suggestion was a request that the TIC provide a larger coverage of gyros and platforms. Additional sources were sought for such information and the entries for gyros and inertial accelerometers in the accession lists were nearly doubled.

The last Quarterly Accessions List published during the current operation period of the TIC was the sixteenth of its type. The total number of abstracts for all accession lists exceeded 1200. Because of the list's comprehensiveness, many users have been utilizing them as their own private information center.

Contract Compilations

Two compilations of transducer research and testing contracts were published during the current period of the TIC operation. This arrangement was believed to have the advantage that both halves of the fiscal year could be covered early. Therefore, when the TIC began its fourth year of operation, it was deemed desirable to publish a compilation of research contracts as soon as possible. The first compilation consisted of 62 items of information. The process of continuing to search for information on research contracts was maintained for the purpose of accumulating information for the second compilation. The second compilation for the period consisted of 40 items of information on current research programs.

Figure 3 presents a flow chart that portrays the method of preparing the research-contract compilations.

Tables of Contents Publications

A monthly compilation of journal tables of contents which would include scientific and technical journals currently being screened by the TIC for information on transducers was published for a portion of this contract year. Editors and publishers of approximately 50 journals were contacted for permission to reproduce pages containing only the tables of contents of their journals. Four such compilations were prepared and distributed. Inquiry forms were included in one of the compilations to sample opinions of the TIC users. Only 10 percent of the forms were returned to the TIC. Seventy-five percent of those returned indicated that the tables of contents compilation was useful and that the monthly compilation should be continued. The remainder of the respondents gave many reasons for requesting that they be excluded from future mailings of the compilation. Because of the poor returns and the indication of some unfavorable reaction plus the burden of the added expense in preparing the compilation, the publication was discontinued after the fourth issue.

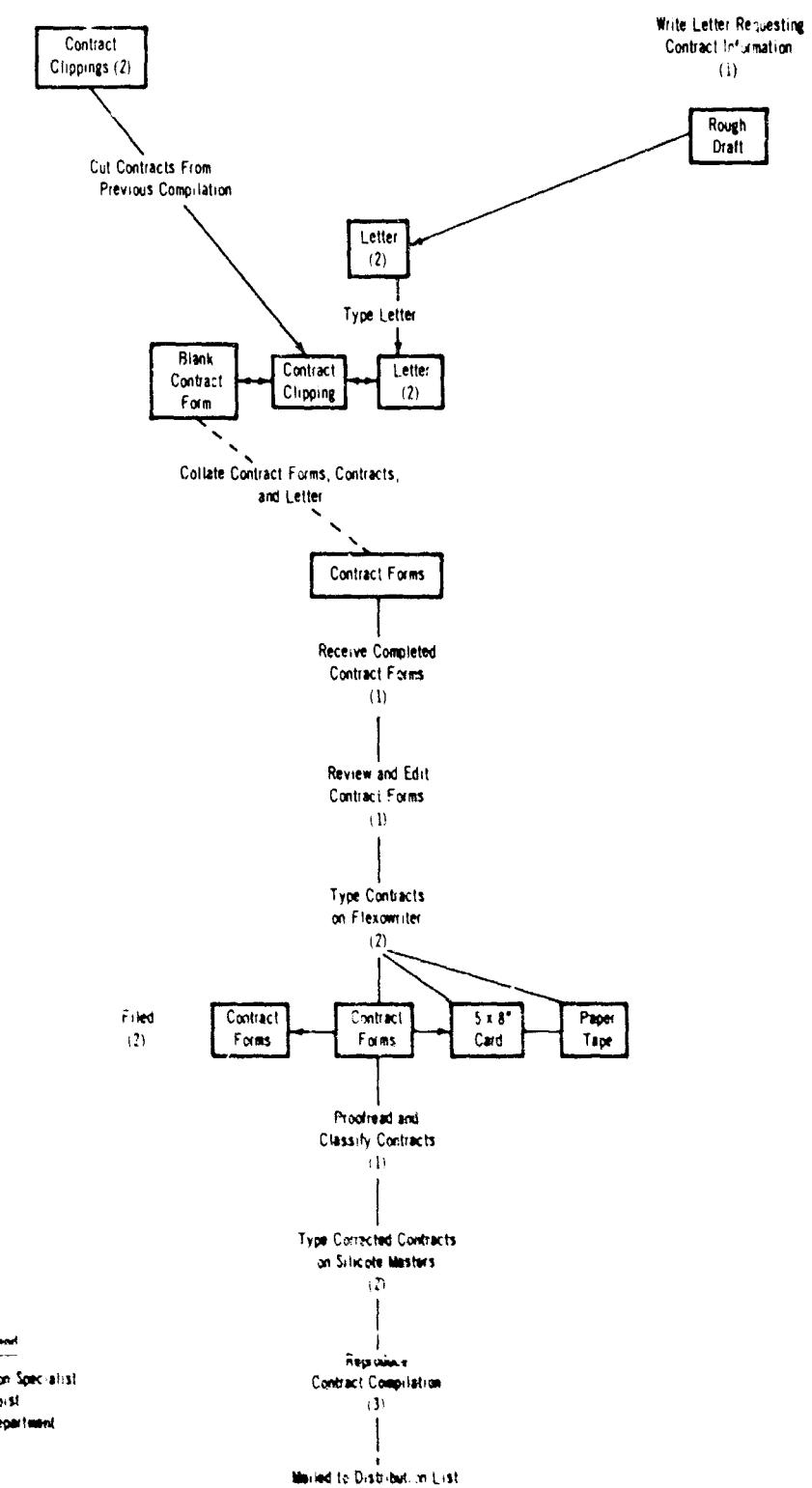


FIGURE 3. PORTRAYAL OF METHODS USED IN PREPARATION OF THE RESEARCH CONTRACT COMPILATION

Summary Report Publication

Because of increasing requests for information covering the effects of nuclear radiation on transducers, the TIC and the Radiation Effects Information Center cooperated in summarizing the information available at both centers. Emphasis was placed on transducer types frequently employed in measurements of pressure, temperature, and forces of acceleration. Other transducer types were covered in depth limited by extent of information that was available. This summary report covered laboratory experiments which have produced data useful in estimating threshold of radiation damages. The information was selected to guide designers, manufacturers, and users in developing a better understanding of the problems that are to be considered in selection of transducers to be used in nuclear environments.

Visitor Services

Twenty-four visitors to the TIC facility were received during the current year of operation. This number represents twice the number of people that visited and used the center files during the past year. The visitors consisted mainly of individuals seeking information on too broad a scale for the TIC staff to handle in the normal fashion and usually covered the entire field for one or more measurands.

User Acceptance

It has been established that one of the methods for determining the value of any information center is by assessment of the number of times a user will return to the center for other information services⁽¹⁾. A study was made to evaluate the TIC on the basis of repeat users between May, 1966 and June, 1967. During this period, the TIC responded to approximately 800 technical and nontechnical inquiries. A breakdown of the single and repeat inquiries is shown in Table VIII.

TABLE VIII. NATURE OF REQUEST REPETITION FOR SERVICES
OBSERVED BETWEEN MAY 1966 AND JULY 1967

Number of Requesters	Number of Repeat Inquiries	Total Number of Inquiries
165	1	165
57	2	114
31	3	93
21	4	84
13	5	65
7	6	42
11	7	77
4	8	32
2	9	18
3	10	30
2	11	22
1	21	21
1	29	29

(1) Walter Carlson, AD HOC Forum of Information Center Managers, November 9-11, 1965, Battelle Memorial Institute, Columbus, Ohio.

It can be seen in Table VIII that almost 48 percent of the 318 requesters provided with transducer information used the TIC more than once during the 14-month period shown. This number represents an increase of 14 percent in repeat users over the previous year which reflects a greater acceptance of the TIC's activities. The time between inquiries by the repeat-group ranged between 2 weeks and 5 months. Thus it can be said that the group using the Center services once consists of many who recently became familiar with the TIC. It was also observed that multiple inquiries from a single company were from a number of different individuals within the organization as contracted with the past where a single person within the company handled all inquiries.

Establishment of a Los Angeles Office

During the previous year of the TIC operation, staff members visited the Los Angeles area for the purpose of discussing the objectives and services of the TIC. It was felt that since there was such a large concentration of potential TIC users in this area, a staff member of the information-research group should be located in the Los Angeles office of Battelle. As a result of this representation, 135 users, manufacturers, and government facilities in the area were visited during the first 10 months, totalling 203 technical or administrative contacts. This number is contrasted with only 19 organizations visited during the previous contract year in the Southern California area. The increased exposure of the technical persons in this area to the services provided by the TIC has resulted in an effective utilization of the technical services made available by the center. The liaison services provided by the Los Angeles representative of the TIC were by far more economical than any attempt to maintain such an activity from the Columbus office of Battelle. This economy was possible since the representative performed similar services for the Radiation Effects Information Center and the Defense Metals Information Center, as well as for the TIC.

Users' Reaction to the TIC Services

Throughout the past 16 months of the TIC operation, careful scrutiny was made of the comments, remarks, criticisms, and suggestions of users to determine their attitudes toward the Center. A review of all trip reports, letters, telephone memorandums, and personal contacts through visits by the users revealed many interesting facts. Nearly all of the individuals on the regular mailing list for the Quarterly Accession Lists agreed that the lists had been useful in maintaining surveillance of transducer activities. A large percentage (60) of the users were chiefly concerned with availability of transducers and found the TIC useful in maintaining awareness of new product developments. Approximately 40 percent of the TIC users who were on the mailing list found the accession lists adequate for their purposes and therefore did not find it necessary to contact the TIC for additional assistance. A majority of the TIC users indicated that they encountered many obstacles in their attempts to obtain documents and articles listed in the accession lists. All of the users of the TIC were highly impressed by the immediate action and attention given to their requests for assistance.

Personal Comments by Users

Nearly all comments received concerning the TIC performance and capabilities have been favorable; some comments involved suggestions that the Center should become

involved with laboratory testing, and others requested increased orientation into industrial applications. Some examples of comments excerpted from letters are as follows:

- (1) "Our use of TIC information is primarily for students and faculty in academic and research activities."
- (2) "An excellent informative service."
- (3) "The publications have been very useful and informative in guiding our research and development programs in the field of temperature and displacement transducers."
- (4) "The dissemination of transducer information by TIC has directly enabled a small research and development firm to expand into biomedical and space instrumentation fields. This has already benefited NASA, NRL, and the Army."
- (5) "The TIC should be continued since it saves time, money, and duplication of effort in the selection and use of transducers for special applications."
- (6) "We believe the service to be of value to our company in the area of search, research, and new ideas."
- (7) "The reports from the Transducer Information Center aid us greatly in keeping abreast with the state of the art in transducers suitable for power reactor environments."
- (8) "This is a valuable service and has been the source of new ideas. It has provided information not otherwise readily available on transducer technology."
- (9) "We review your abstract bulletin and find it extremely useful in our EPIC program. We would endorse its continuation."
- (10) "We quite often reference reports included in your quarterly summary to our customers."
- (11) "The publications that we receive from you have been used and have helped our instrumentation engineers to keep up with the current happenings in the field."
- (12) "Your services certainly have saved us many engineering hours."
- (13) "This service has been a great help to us in the specific area of flow and temperature transducers."
- (14) "This center helps us not to duplicate costly projects; thus savings are tangible for all governmental agencies."
- (15) "Basic value is found in making correct design decisions. Much development effort is saved."

- (16) "Excellent - keep up the work - fills a much needed gap."
- (17) "One can say that better performance is being obtained, no significant and fruitful areas have been overlooked; it is felt that the AF and have both been greatly helped by TIC."
- (18) "Readily available TIC reference material has reduced, and in some cases eliminated, literature searches conducted for transducer-related projects."
- (19) "TIC reports are stored in our library for ready access when needed. Reviewing the reports serves to keep us abreast of latest developments."
- (20) "The TIC has aided us considerably by keeping us abreast of new transducers, especially in the geophysical area."
- (21) "The TIC serves a most useful function -- it saves a good bit of search time."

CONCLUSIONS

During this fourth year of the TIC operation, the Center has found a pronounced increase in the awareness and acceptance of its services by manufacturers, researchers, and users of transducers. This applies to both industry and the various government agencies. This increase was shown by the rapid increase in the number of users of the Center, the number of requests for assistance, and the significant increase in the flow of information from all sources to the Center. A substantial increase occurred in technical and nontechnical requests during the fourth year of operation.

Of the services provided by the Center, the Quarterly Accessions Lists continue to receive wide acceptance and the most favorable reaction. A review of comments on this publication indicated that it will continue to be the most popular product of the Center. According to information received from the Defense Documentation Center and the Federal Clearinghouse for Scientific and Technical Documents, 235 copies of the accessions lists, 120 copies of the compilation of transducer research and testing contracts, 229 copies of the summary report on digital transducers, and 62 copies of the report on force transducers were supplied to requesters. Two hundred thirty-eight copies of TIC final reports were distributed by the documentation centers. It is also believed that the TIC Summary Report No. 3 covering nuclear radiation effects on most of the frequently used transducers will find broad usage in the nuclear-rocket space program as well as in atomic energy. The research-contract compilation continues to be evaluated as a useful effort by research development directors, market researchers, and the various government agencies who plan future programs.

To some extent, the TIC has been maintaining awareness of transducers for use in fluidics as applied to computers, oceanographic instrumentation, and medical electronics. No major demands have been made on the Center in these areas since the TIC has not indicated its capabilities in these fields. It is felt that the Center should not emphasize these technologies until it has collected sufficient information to satisfy requests for services.

The value of the Center to users from the standpoints of tangible savings incurred and demonstrated by repeat-users was clearly shown in the study of TIC performance. According to information provided by the users of the Center during the previous year, approximately \$463,000, or more than six times the TIC funding, was estimated as the total savings. During the current year \$495,770 was indicated by more than 35 percent of the users who responded to inquiries on such information. Over 42 percent of TIC inquiries came from individuals who used the center more than once during this year.

RECOMMENDATIONS

- (1) The Transducer Information Center should be continued in its present form. The scope of activities should continue according to the present objectives and mode of operation, with additional funding to support its growth of services and activities.
- (2) The 16 accessions lists produced by the TIC to date should be combined into one publication because they have become a valuable research tool for individual studies.
- (3) The accessions lists should be published on a bimonthly basis, since it is believed that information can be processed to reduce the time lag between acquisition and the organization of the list for publication.
- (4) It is recommended that the operation be supported with Government funds from any agency that has found the Center of use to their research and development programs. Funding of the Center would introduce severe problems in connection with report acquisition as the TIC would face difficulties in qualifying at the documentation centers.
- (5) New considerations should be given to publishing monthly compilations of tables of contents from journals which occasionally contain articles on transducers. The major difference in handling the compilation would be in connection with the manner of distribution. All TIC users should be required to request monthly copies of the compilation as opposed to providing automatic mailing.
- (6) Efforts should be continued to accumulate information on transducers that will play an important role in fluidics and liquid metals.
- (7) Some consideration should be given to preparing a summary report on subjects of growing interest. Typical subjects consist of transducers in fluid systems, liquid metals, and integrated transducers. Another subject, but one which would require considerable manpower and expenditure, would be a study of transducer performance requirements for future telemetry systems.
- (8) Representation of the TIC should be continued in the Southern California area and some consideration should be given for having a representative at Huntsville, Alabama, and Boston, Massachusetts.

LIST OF AVAILABLE TIC PUBLICATIONS

Transducer Information Center
Columbus Laboratories
Battelle Memorial Institute
Columbus, Ohio

Requests for unclassified information or unclassified TIC published reports and accessions lists should be sent to:

Transducer Information Center
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
Attention W. E. Chapin

Quarterly Accession Lists

<u>Accession List Number</u>	<u>Date of List</u>
1	July 15, 1963
2	October 15, 1963
3	January 15, 1964
4	April 15, 1964
5	July 15, 1964
6	October 15, 1964
7	January 15, 1965
8	April 15, 1965
9	July 15, 1965
10	October 15, 1965
11	January 3, 1966
12	April 1, 1966
13	August 15, 1966
14	November 15, 1966
15	February 1, 1967
16	May 15, 1967

Research Contract Compilations

<u>Compilation No.</u>	<u>Date of Publication</u>
1	January 15, 1965
1 (First Addendum)	April 15, 1965
2	January 15, 1965
3	September 1966
4	February 1967

Final Reports

<u>Report Number</u>	<u>Title</u>	<u>Date</u>
FDL-TDR-64-63	A Study of Requirements for Establishment and Operation of a Transducer Information Center	March 1964
AFFDL-TR-65-30	Continuation of the Small-Scale Operation of a Transducer Information Center	April 15, 1965
AFFDL-TR-66-66	Continuation of the Small-Scale Operation of a Transducer Information Center	April 1, 1966
AFFDL-TR-67-154	Operation of a Transducer Information Center	November 1967

Unclassified Reports

<u>Report Number</u>	<u>Title</u>
1	A Summary of Digital-Transducer Developments and Techniques (July 15, 1965)
2	A Summary of Force-Transducer Technology: Measurement Techniques, Calibration, Element Design, Availability, and Research Activity (April 1966)
3	The Effect of Nuclear Radiation on Transducers (October 31, 1966)

Unclassified

Security Classification

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13. ABSTRACT This is the final report covering the activities of the Transducer Information Center (TIC) for the past 16 months of operation at Battelle Memorial Institute under Air Force Contract No. AF 33(615)-5158., Task No. 822203 of Project No. 8222. This project involved the collection and processing of all categories of transducer documents, data, literature, and reports into a storage-and-retrieval system. The Center made this information available to the transducer community on request by publishing accession lists or abstracts, research-contract compilations, a summary report covering nuclear radiation effects on transducers, and a monthly compilation of journal tables of contents. Members of the Center visited with manufacturers and users of transducers where discussions were held on the program objectives and the Center services. Over 1000 requests for technical and nontechnical assistance were handled by the Center specialists. In its fourth year of operation, the Center has experienced a growth from a small-scale or pilot transducer information center to one which has met with favorable reaction and acceptance by its users.		

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	ROLE	WT	ROLE	WT	ROLE	WT
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Processing	8					
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Documents	9, 1					
Information	9, 1					
Data	9, 1					
Literature	9, 1					
Reports	9, 9					
Transducers	9, 4					
Operations	8					
Information Centers	9					
Information Systems	9					
Transducer Information Center	9					
Accessions Lists	8					
Abstracts	8					
Compilations	8					
Contracts	8, 9					
Research	8, 9					
Sensors	8, 4					
Pressure Transducers	8, 4					
Conferences	8, 9					
Acquisition	8					

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